

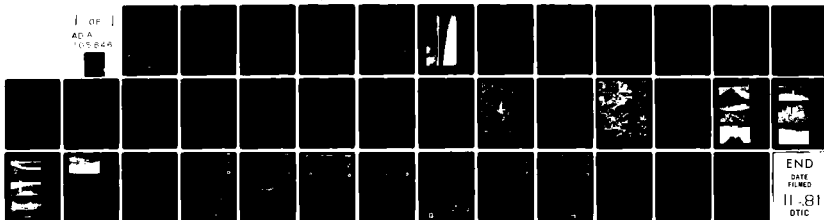
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NATIONAL DAM SAFETY PROGRAM. BETHANY NEW CITY RESERVOIR DAM (MO--ETC(U)
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MISSOURI **LEVEL II** 155 **(1)**
MISSOURI-GRAND-CHARITON BASIN
AD A105646

BETHANY NEW CITY RESERVOIR
HARRISON COUNTY, MISSOURI
MO 10071

10 Final rept.,

15 DACW43-78-C-0155

10 Harold P. /Hoskins

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM.

Bethany New City Reservoir Dam (MO 10071),
Missouri - Grand - Chariton Basin,
Harrison County, Missouri. Phase I Inspection
Report.

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PREPARED BY: HOSKINS-WESTERN-SONDEREGGER, INC.
FOR: STATE OF MISSOURI

JUL 1978

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1. REPORT NUMBER	2. GOVT ACCESSION NO. <i>AD-A105 646</i>	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Phase I Dam Inspection Report National Dam Safety Program Bethany New City Reservoir Dam (MO 10071) Harrison County, Missouri		5. TYPE OF REPORT & PERIOD COVERED Final Report
7. AUTHOR(s) Hoskins-Western-Sonderegger, Inc.		6. PERFORMING ORG. REPORT NUMBER
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101		8. CONTRACT OR GRANT NUMBER(s) DACW43-78-C-0155
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		12. REPORT DATE July 1978
		13. NUMBER OF PAGES Approximately 35
		15. SECURITY CLASS. (of this report) UNCLASSIFIED
16. DISTRIBUTION STATEMENT (of this Report) Approved for release; distribution unlimited.		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Dam Safety, Lake, Dam Inspection, Private Dams		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.		

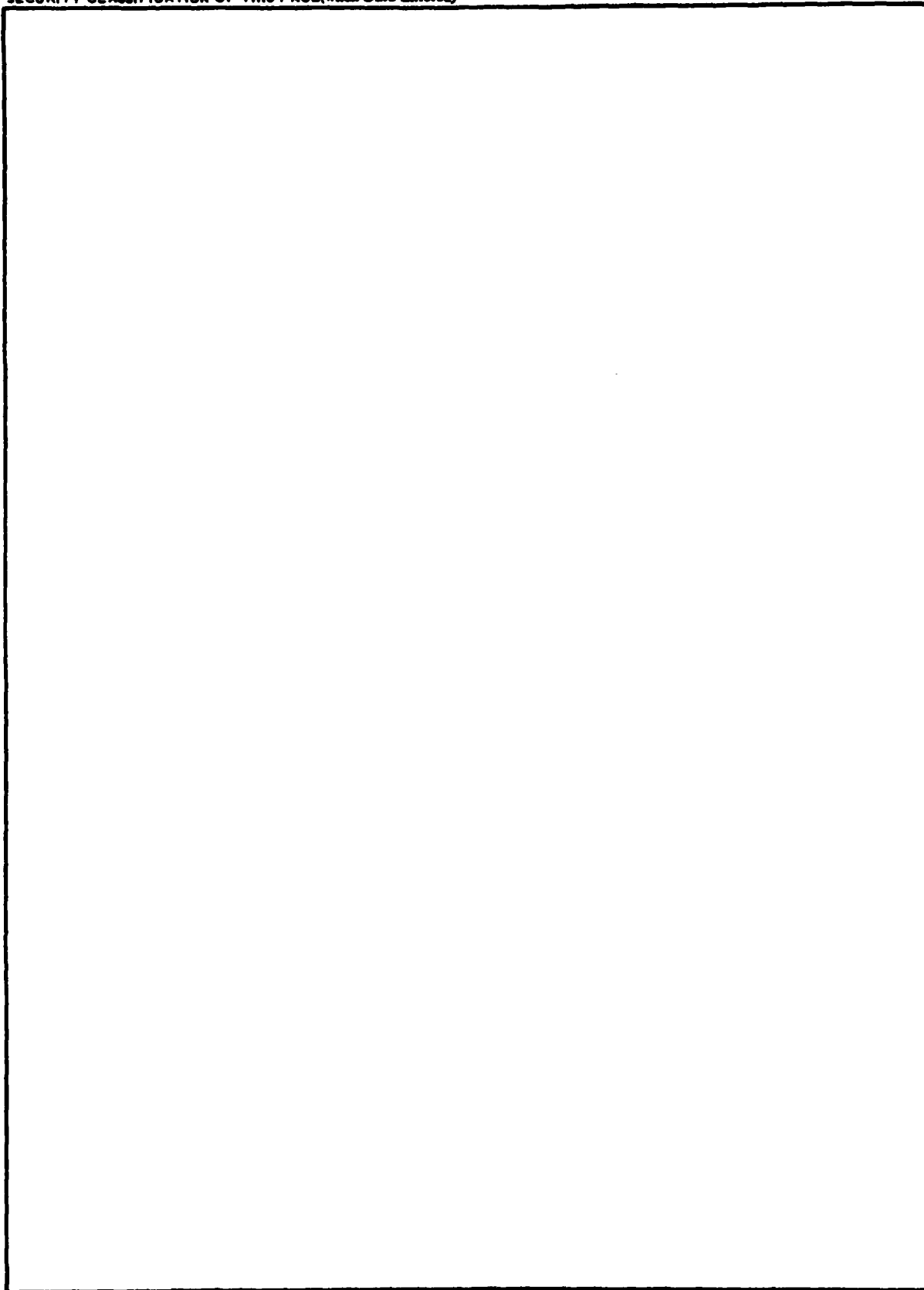
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PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam	Bethany New City Reservoir Dam
State Located	Missouri
County Located	Harrison County
Stream	Tributary to West Fork of Big Creek
Date of Inspection	July 20, 1978

↓
Bethany New City Reservoir Dam was inspected by an interdisciplinary team of engineers, ~~from Hoskins-Western-Sonderregger, Inc.~~ The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers and developed with the help of several Federal and State agencies, professional engineering organizations, and private engineers. Based on these guidelines, this dam is classified as an intermediate size dam with a high downstream hazard potential. Failure would threaten life and property. The estimated damage zone extends six miles downstream of the dam. The damage zone runs along the edge of the town of Bethany, Missouri, (population 2,900) which is about two miles downstream of the dam. Within the damage zone are four homes with farm buildings, five improved road bridges and one railroad bridge. The floodplain is farmed.

Our inspection and evaluation indicates that the spillway does meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillway will pass the Probable Maximum Flood without overtopping the dam. The Probable Maximum Flood (PMF) is defined as the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. Additional deficiencies, in accordance with the guidelines, are the lack of seepage and stability analysis. These analyses should be obtained in the future.

Other deficiencies visually observed by the inspection team were small trees and brush growing on the upstream embankment slope, some trees growing in the spillway channel and erosion of the spillway channel downstream from the sill.

9

1

Several items of preventive maintenance need to be initiated by the owner. These are described in detail in the body of the report. Copies of the report have been furnished the dam owner and the Governor of Missouri.

H. P. Hoskins E8696
 Harold P. Hoskins, P.E.
 Hoskins-Western-Sonderegger, Inc.
 Lincoln, Nebraska

SIGNED

SUBMITTED BY _____
 Chief, Engineering Division

29 SEP 1979
 Date

APPROVED BY _____
 Colonel. CE. District Engineer

29 SEP
 Date

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PHOTOGRAPH NO. 1
OVERVIEW OF LAKE AND DAM,
TAKEN FROM NORTH LOOKING
SOUTH. DAM IN CENTER OF
PHOTOGRAPH.

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
BETHANY NEW CITY RESERVOIR DAM - ID No. M010071

TABLE OF CONTENTS

<u>Paragraph No.</u>	<u>Title</u>	<u>Page No.</u>
SECTION 1 - PROJECT INFORMATION		
1.1	General	1
1.2	Description of Project	1
1.3	Pertinent Data	2
SECTION 2 - ENGINEERING DATA		
2.1	Design	5
2.2	Construction	5
2.3	Operation	5
2.4	Evaluation	5
SECTION 3 - VISUAL INSPECTION		
3.1	Findings	6
3.2	Evaluation	7
SECTION 4 - OPERATIONAL PROCEDURES		
4.1	Procedures	8
4.2	Maintenance of Dam	8
4.3	Maintenance of Operating Facilities	8
4.4	Description of Any Warning System in Effect	8
4.5	Evaluation	8
SECTION 5 - HYDRAULIC/HYDROLOGIC		
5.1	Evaluation of Features	9
SECTION 6 - STRUCTURAL STABILITY		
6.1	Evaluation of Structural Stability	10
SECTION 7 - ASSESSMENT/REMEDIAL MEASURES		
7.1	Dam Assessment	11
7.2	Remedial Measures	11

APPENDIX A - MAPS

Plate 1	Vicinity Topography
Plate 2	Location Map
Plate 3	Orthophotograph

APPENDIX B - PHOTOGRAPHS

Photographs of Dam and Lake (No. 2 through No. 11)

APPENDIX C - PLANS AND REPORTS

Larkin & Assoc.	Dams and Borrow Areas
" "	Profile of Dam
" "	Plan of Dam
" "	Typical Cross Sections
" "	Dam Appurtenances
" "	Boring Logs
" "	Spillway

APPENDIX D - HYDROLOGIC COMPUTATIONS

Plate D1	Inflow Hydrographs
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SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection of the Bethany New City Reservoir Dam be made.

b. Purpose of Inspection. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

c. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams." These guidelines were developed with the help of several Federal agencies and many State agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances.

(1) The dam is an earth fill built in a "U" shaped valley. Slopes adjacent to the dam are gently rolling. Soils on the slopes are derived from fine grained plastic glacial till.

(2) A spillway is cut through the right (west) abutment. The control section of this spillway consists of a one foot wide concrete sill.

(3) Controlled discharge facilities consist of a concrete gate tower and inlet connected to a 16 inch diameter cast iron pipe-line passing through the base of the dam to supply water for the City of Bethany.

(4) Pertinent physical data are given in Paragraph 1.3 below

b. Location: The dam is located in the central portion of Harrison County, Missouri, as shown on Plate 2. The reservoir formed by the dam is shown on Plate 1 in the E $\frac{1}{2}$ Sec. 27, T63N, R28W and in the W $\frac{1}{2}$ Sec. 26, T63N, R28W. The reservoir is also shown on the Bethany SE Orthophotograph (Plate 3).

c. Size Classification. Criteria for determining the size classification of dams and impoundments are presented in the guidelines referenced in paragraph 1.1c above. Based on these criteria, this dam and impoundment is in the intermediate size category.

d. Hazard Classification. Guidelines for determining hazard classification are presented in the same guidelines as referenced in paragraph c above. Based on referenced guidelines, this dam is in the High Hazard Classification. The estimated damage zone extends six miles downstream of the dam. The damage zone runs along the edge of the town of Bethany, Missouri, (population 2,900) which is about two miles downstream of the dam. Within the damage zone are four homes with farm buildings, five improved road bridges and one railroad bridge. The floodplain is farmed.

e. Ownership. This dam is owned by the City of Bethany, c/o Mike Roscoe, City Administrator, Bethany, Missouri 64424.

f. Purpose of Dam. The dam forms a 130 acre municipal water supply reservoir (Area based on elevation of spillway sill).

g. Design and Construction History. The dam was designed by Larkin and Associates, Kansas City, Missouri and was built in 1960. Pertinent portions of construction plans are shown in Appendix C. No other design or construction data were available.

h. Normal Operating Procedure. The spillway for the dam is uncontrolled. The controlled discharge facilities are a part of the water supply system for the City of Bethany. Water supply discharges from this lake are interconnected with the supply system from the Bethany City Reservoir located about 1.75 miles south and downstream from this reservoir.

1.3 PERTINENT DATA

a. Drainage Area - 733 acres (1.145 square mile)

b. Discharge at Damsite.

(1) All discharge at the damsite is through an uncontrolled grassed earth channel ungated emergency spillway with reinforced concrete sill with riprap upstream and downstream on the side slopes.

(2) Estimated maximum flood at damsite-unknown.

(3) The spillway capacity at PMF pool elevations (925.91 ft.) is 3,000 c.f.s.

c. Elevations (Feet above M.S.L., - note that project datum was 7.36 feet higher than U.S.G.S. datum).

- (1) Top of dam - 926.5 (minimum by field survey)
- (2) Spillway sill - 919.6
- (3) Streambed at centerline of dam - 865₊
- (4) Maximum tailwater - unknown.

d. Reservoir. Length of maximum pool - 4400₊

e. Storage (Acre-feet)*

- (1) Top of dam - 3850
- (2) Spillway sill - 2820

*(From computed storage-elevation curve)

f. Reservoir Surface (Acres)*

- (1) Top of dam - 153
- (2) Spillway sill - 130V

*(From computed area-elevation curve)

g. Dam

- (1) Type - earth embankment
- (2) Length - 1000 feet
- (3) Height - 60₊ maximum. (Measured with Abney hand level)
- (4) Top width - 20 feet
- (5) Side slopes
 - (a) Downstream - 3H on 1V with 26 to 30 foot berm at elevation 896.6₊
 - (b) Upstream - 3H on 1V

(6) Zoning - Plans show impervious fill in the center and upstream section with random fill in the downstream section.

(7) Impervious core - Yes

(8) Cutoff - The plans show a compacted clay cutoff located just upstream from centerline of dam and averaging about 10 feet in depth. The bottom of the cutoff trench is excavated into limestone, shale or fat clay (CH) material.

(9) Grout Curtain - No

(10) Wave protection - Rip rap

(11) Drains - A 50'± wide drainage blanket is shown on the plan and typical cross section sheets in Appendix C. An 18" perforated corrugated metal pipe was installed in the downstream side of the blanket from Station 3+25 to Station 7+25. Three 12" corrugated metal drain pipes are connected to the 18" perforated pipe at Stations 4+30, 4+60 and 6+00. The 12" pipes surface at the downstream toe. A trickle of clear water was being discharged from the drain located at Station 4+30 at the times of inspection.

h. Diversion and Regulating Tunnel - None

i. Spillway

(1) Type - Grassed earth channel with 1 foot wide reinforced concrete sill.

(2) Length of sill - 50 feet.

(3) Sill elevation - 919.6 feet.

(4) Side slopes - 3(h): 1(v)

(5) Channel slope - upstream from sill - 1%; downstream from sill 2%

(6) Riprap - On side slopes 50 feet upstream and downstream from sill.

j. Regulating outlets - Concrete gate tower and inlet connected to a 16-inch diameter cast iron pipe line passing through the base of the dam to supply water for the City of Bethany. The Typical Cross Section sheet (Appendix C) shows nine seepage collars were to be constructed around the outlet pipe in the impervious fill portion of the dam. This outlet is not considered in the hydrologic analysis of the dam.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Design data that were available are shown in Appendix C. The dam appears to have been constructed according to the plans. Materials shown in the borrow areas used to construct the dam were logged as clays and clays (CL and CH). The foundation materials were logged as stiff to very stiff CL and CH soils (liquid limits = 40-70, plasticity index 20-50) overlying horizontally bedded limestone and shale.

2.2 CONSTRUCTION

No construction data were available.

2.3 OPERATION

The maximum water level attained in the reservoir is not known. The water level appears to be quite stable. The operating facilities for this dam make up a portion of the Bethany City water supply system. No records were reviewed relating to water supply discharges.

2.4 EVALUATION

a. Availability. Data shown in Appendix C were available from Larkin and Associates. The extent of additional design and construction data available from Larkin and Associates is not known.

b. Adequacy. The engineering data available were not sufficient to make a detailed assessment of design and construction.

c. Validity. Available data are considered to be valid.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of Bethany New City Reservoir dam was made July 20, 1978. Engineers from Hoskins-Western-Sonderegger, Inc., Lincoln, Nebraska, participating in the inspection were: Rey Decker and Steve Nickel, Geology and Soils Engineering; Garold Ulmer, Civil Engineer, Richard Walker, Hydrology. Local information on the dam was supplied by Mike Roscoe, Bethany City Administrator and Mrs. Premer, City Clerk.

b. Dam. A few small trees are growing on the upstream face of the dam. The riprap on the upstream slope looked good. No slides or erosion was noted on the upstream slope.

The crest of the dam is covered with road gravel and is well maintained. No cracks or abnormal deformations were noted on the crest. The downstream slope is well vegetated with alfalfa or vetch, brome and other grasses. It appeared to have been mowed quite recently. There were no indications of seepage, slides or deformations on the downstream slope or along the downstream toe. The drain outlet on the left (east) side of the downstream slope was discharging a bare trickle of clear water. There was no indication that the drain outlets have ever discharged very much water. Both abutments consist of stiff, silty clays (CL or CH) overlying alternate beds of limestone and shale. Some of the shale members (as exposed in the spillway channel) are indurated and almost fissile. No slides, seeps or deformations were noted in the abutments.

c. Appurtenant Structures.

The spillway consists of an approach channel about 55 feet in width with side slopes of 3H on 1V excavated into silty clay and gravelly clay on the right abutment. The bottom of the approach channel is well vegetated with grasses. The side slopes of the channel are plated with poor quality limestone which shows some deterioration. The control section of the spillway consists of a 12 inch wide concrete sill across the bottom. No deterioration was noted in the concrete sill. Several trees up to 4 to 6 inches in diameter are growing in the channel at the control section. Some erosion was noted in the exit channel. The eroded section of the channel extends about 150 feet downstream from the sill. Silty clay shale is exposed in the lower end of the eroded spillway channel.

No slides or sloughs were noted in the spillway.

The spillway was discharging a slight flow (1 to 2 gal/min/ at the time of the inspection.

The concrete gate tower looked good and it is assumed that all valves and gates are operable since this reservoir supplies water to the City of Bethany.

d. Reservoir Area. Some bank erosion was noted along the west (right) side of the spillway forebay area. A raw bank was also noted along the west shoreline of the lake approximately 0.25 miles upstream from the dam. The remainder of the shoreline looked good with no significant erosion, sloughs or slides.

e. Downstream Channel. The spillway channel discharges over the gravel road traversing the dam and outlets into a side drainage 800 to 1000 feet downstream from the road. No significant erosion or obstructions were noted in the outlet channel.

3.2 EVALUATION

The dam looks very good. The visual observations and the few rough measurements made by the inspection team using an Abney hand level and stadia board indicate that this dam was constructed according to the plans shown in Appendix C. None of the conditions observed are significant enough to indicate a need for immediate remedial action or potential of failure. Vegetation on the upstream slope and trees and erosion in the spillway channel could ultimately lead to potential of failure if left uncontrolled.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

Operating and regulating procedures for this dam are dependent upon the demand for water from this reservoir by the City of Bethany.

4.2 MAINTENANCE OF DAM

In general, the dam is well maintained. The few deficiencies in maintenance that were observed are discussed in Section 3.

4.3 MAINTENANCE OF OPERATING FACILITIES

The inspection team is not aware of any deficiencies in maintaining the operating facilities at this dam.

4.4 DESCRIPTION OF WARNING SYSTEM IN EFFECT

The inspection team is not aware of any existing warning system for this dam.

4.5 EVALUATION

Trees on the upstream face of the dam and trees and erosion in the spillway could lead to potential failure if left uncontrolled.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. Pertinent hydraulic and hydrologic data which were taken from as-built plans furnished by the consulting engineers (Hoskins and Associates) are tabulated in Appendix D on Hydrologic Computations. The supporting computations are attached.

b. Experience Data. The drainage area, water surface areas, and volumes were developed from the U.S.G.S. Bethany, MO. (15') Topographic Quadrangle. The hydraulic computations for the spillway and possible dam overtopping discharge ratings were made using the as-built plans and surveys made during the inspection. There were no major discrepancies discovered as far as the hydraulic structural components of the dam and spillway were concerned.

c. Visual Observations. The spillway consists of an approach channel about 55 feet in width with side slopes of 3H on 1V excavated into silty silt and gravelly clay on the right abutment. The bottom of the approach channel is well vegetated with grasses. The side slopes of the channel are plated with poor quality limestone which shows some deterioration. The control section of the spillway consists of a 12 inch wide concrete sill across the bottom. No deterioration was noted in the concrete sill. Several trees up to 4 to 6 inches in diameter are growing in the channel at the control section. Some erosion was noted in the exit channel. The eroded section of the channel extends about 150 feet downstream from the sill. Silty clay shale is exposed in the lower end of the eroded spillway channel.

No slides or sloughs were noted in the spillway.

d. Overtopping Potential. The spillway will carry the probable maximum flood without overtopping the dam.

According to the recommended guidelines from the Department of the Army, Office of the Chief of Engineers, this dam is classified as intermediate size by height and storage and has a high hazard classification. Therefore, the PMF is the test for the adequacy of the dam and its spillway.

The estimated damage zone extends six miles downstream of the dam. The damage zone runs along the edge of the town of Bethany, Missouri, (population 2,900) which is about two miles downstream of the dam. Within the damage zone are four homes with farm buildings, five improved road bridges and one railroad bridge. The floodplain is farmed. This information was furnished by the St. Louis District, Corps of Engineers in a letter dated 13 July 1978.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Deficiencies which could ultimately affect structural stability are discussed in Section 3.

b. Design and Construction Data. Design and construction data that were available are not adequate to make a detailed evaluation of the structural stability of this dam.

c. Operating Records. The spillway is uncontrolled on this dam and operational records would consist of data relative to the City water demands and consumption. No operational records were reviewed by the inspection team.

d. Post construction changes. The inspection team is not aware of any post construction changes on this structure.

e. Seismic Stability. This dam is located in Seismic Zone 1. An earthquake of this magnitude is not expected to cause a structural failure of this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. The few maintenance deficiencies noted during the visual inspection and discussed in Paragraph 7.2 below, should be corrected or controlled. The dam appears to have been constructed according to the plans. The maximum design flood will not overtop the dam.

b. Adequacy of Information. Detailed design and construction data were not available. However, the data that were available, the performance history of the dam, and the visual observations are considered sufficient to support the conclusions reported herein. Neither seepage nor stability analyses were found which is a deficiency that should be corrected in the future.

c. Urgency. The remedial measures recommended in Paragraph 7.2 should be accomplished in the near future.

d. Necessity for Phase II. Phase II investigations are not considered to be necessary for this structure.

e. Seismic Stability. This dam is in Seismic Zone 1. An earthquake of this magnitude is not expected to be hazardous to this dam.

7.2 REMEDIAL MEASURES

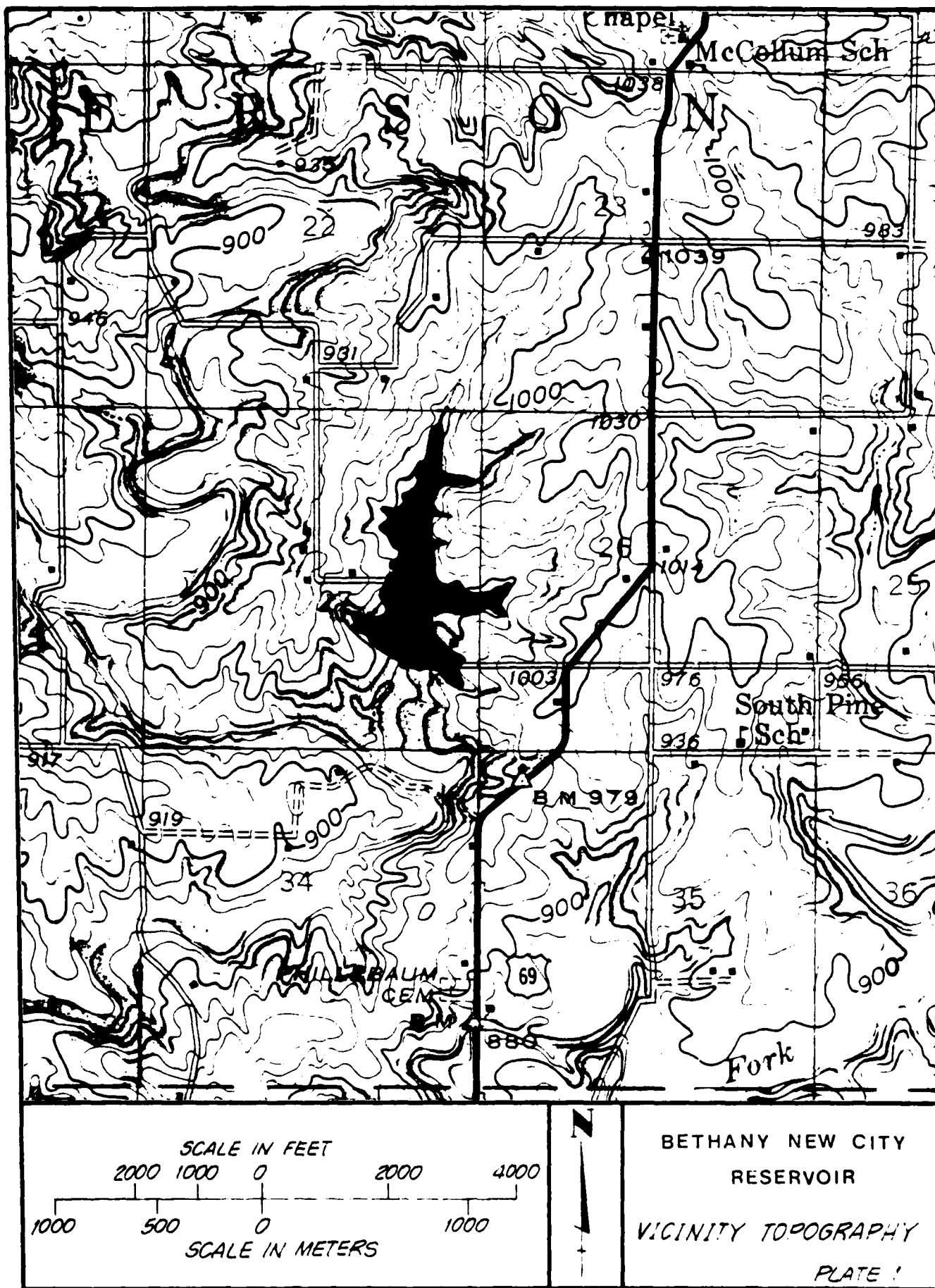
a. O & M Maintenance and Procedures.

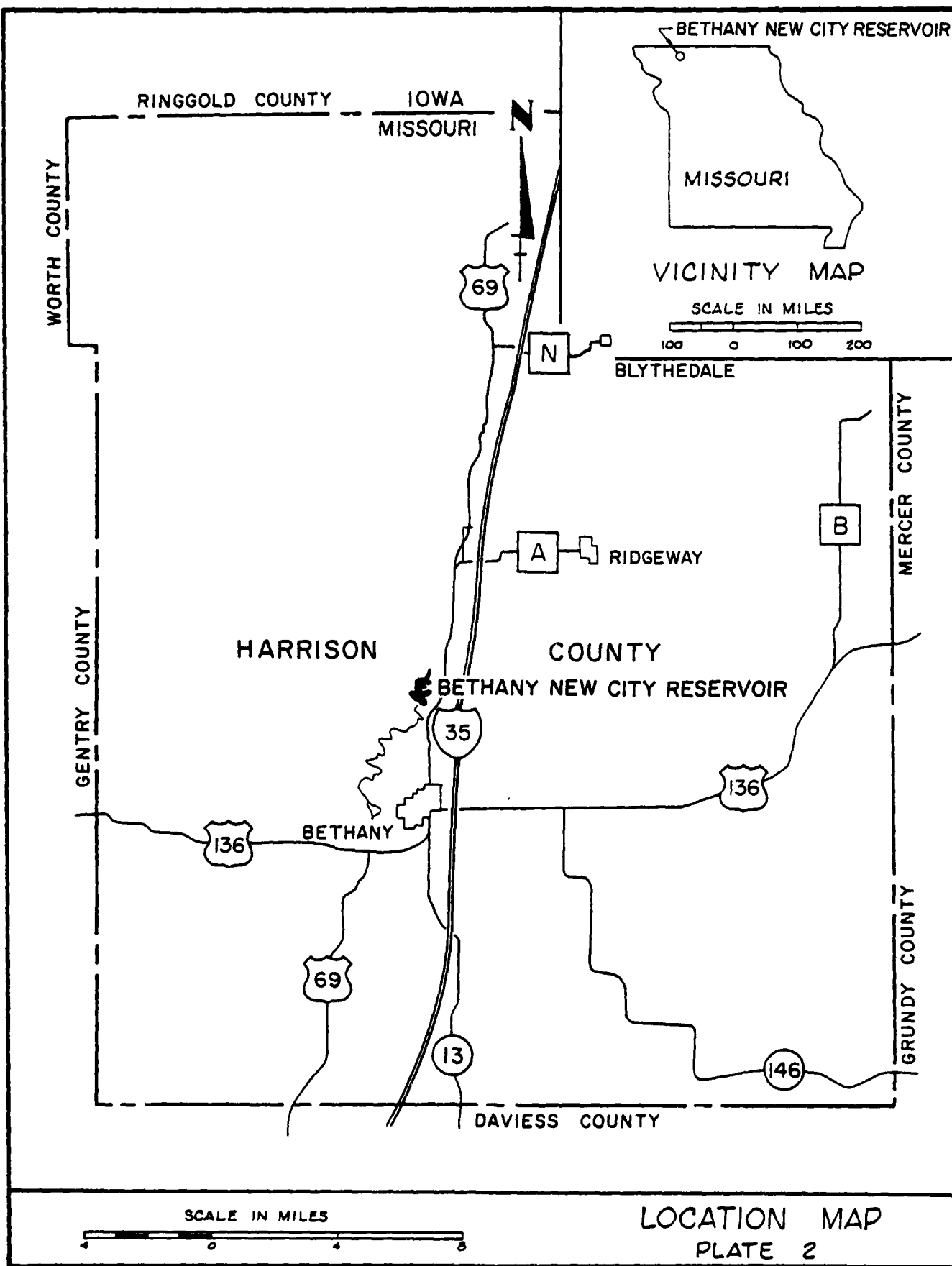
(1) Trees and brush on the upstream slope of the dam and in the spillway should be removed and measures initiated to prevent their recurrence.

(2) Erosion in the spillway exit channel should be corrected.

(3) Annual inspections of the dam should be scheduled to insure that vegetative growth and spillway erosion is controlled.

APPENDIX A
MAPS





LOCATION MAP
PLATE 2



SCALE IN FEET

2000 1000 0 2000 4000
1000 500 0 1000

SCALE IN METERS



BETHANY NEW CITY
RESERVOIR
ORTHOPHOTOGRAPH
PLATE 3

APPENDIX B
PHOTOGRAPHS



PHOTO NO. 2
TOP OF DAM.
LOOKING WEST
FROM EAST END.



PHOTO NO. 3
DOWNSTREAM
OUTLET CHANNEL
OF SPILLWAY
TAKEN FROM
SILL.



PHOTO NO. 4
EROSION OF
SILTSTONE IN
OUTLET CHANNEL
DOWNSTREAM
FROM SILL.
LOOKING UPSTREAM.



PHOTO NO. 5
GATE TOWER FROM
CENTERLINE OF
DAM LOOKING
UPSTREAM.



PHOTO NO. 6
12" DRAIN OUTLET
STATION 3+60.
BARELY DRIPPING.



PHOTO NO. 7
LOOKING WEST
ACROSS BERM
ON DOWNSTREAM
SLOPE.



PHOTO. NO. 8
OVERVIEW FROM
ROAD ENTRANCE
ON EAST SIDE
OF LAKE.



PHOTO. NO. 9
UPSTREAM FACE
TAKEN FROM EAST
ABUTMENT.

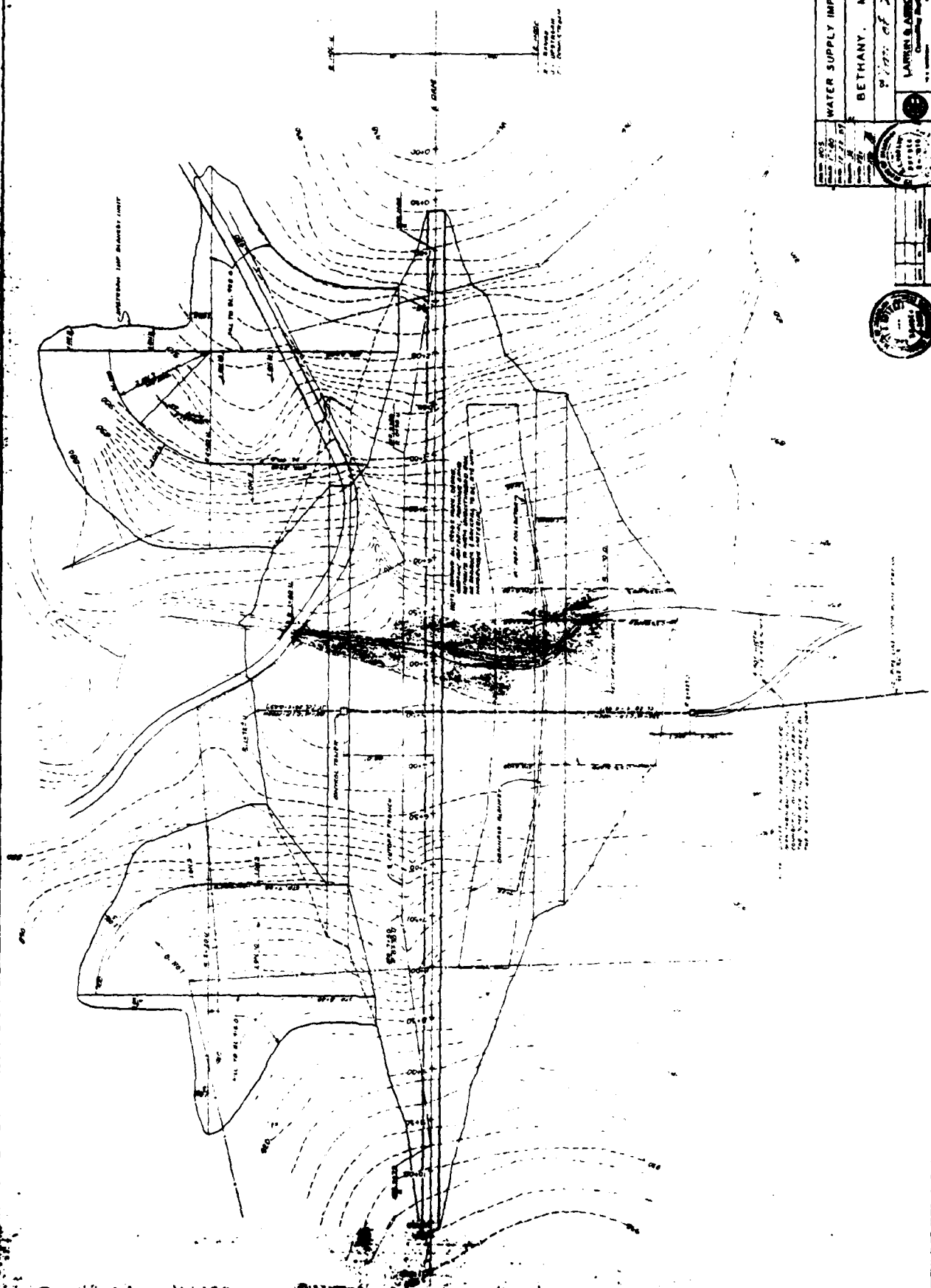


PHOTO. NO. 10
SPILLWAY. ROD
ON SILL. LOOKING
DOWNSTREAM.

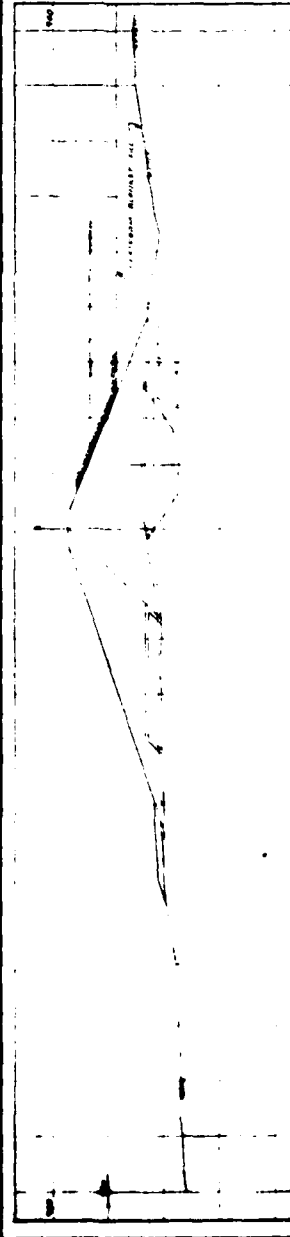


PHOTO. NO. 11
FOREBAY OF
SPILLWAY TAKEN
FROM SILL LOOKING
UPSTREAM.

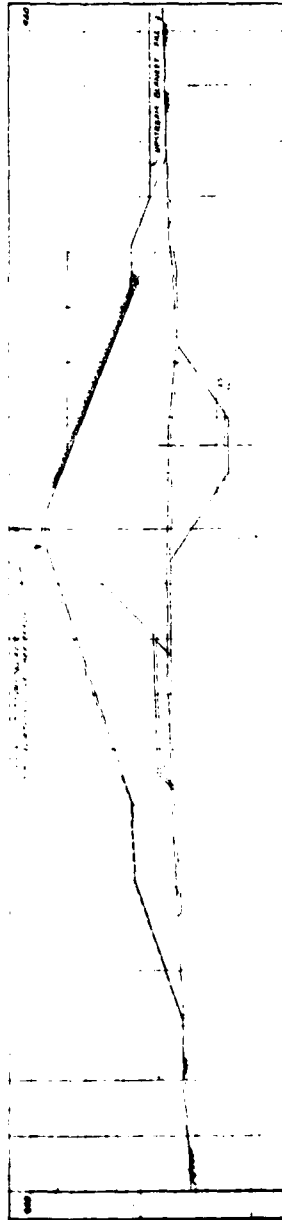
APPENDIX C
PLANS AND REPORTS



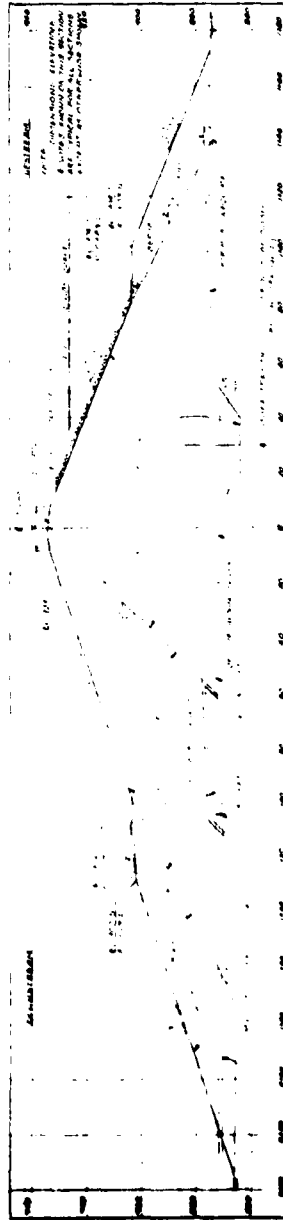
WATER SUPPLY IMPROVEMENTS
BETHANY, MISSOURI
Plan of Dam
LAREN & ASSOCIATES
Engineers
St. Louis, Mo.



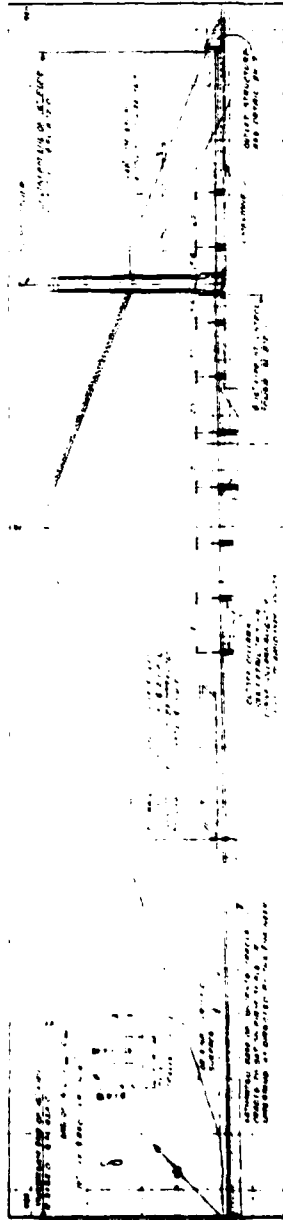
STATION 2+50



STATION 3+50



STATION 4+50



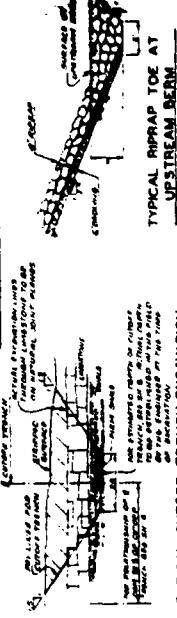
STATION 5+50



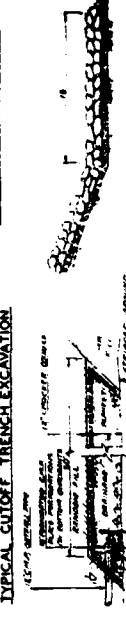
STATION 2+00



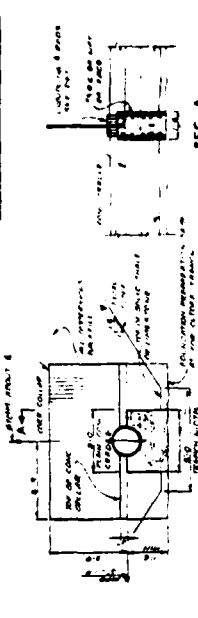
STATION 3+00



TYPICAL RIPRAP TOE AT
UPSTREAM BERM

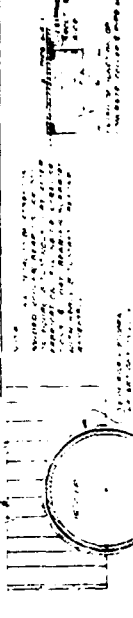


TYPICAL RIPRAP TOE AT
UPSTREAM BLANKET FILL
AND ABUTMENTS



SEC. A

DETAILS OF CONCRETE GRADE & CUTOFF COLLARS



DETAIL - METAL COLLAR

WATER SUPPLY IMPROVEMENTS

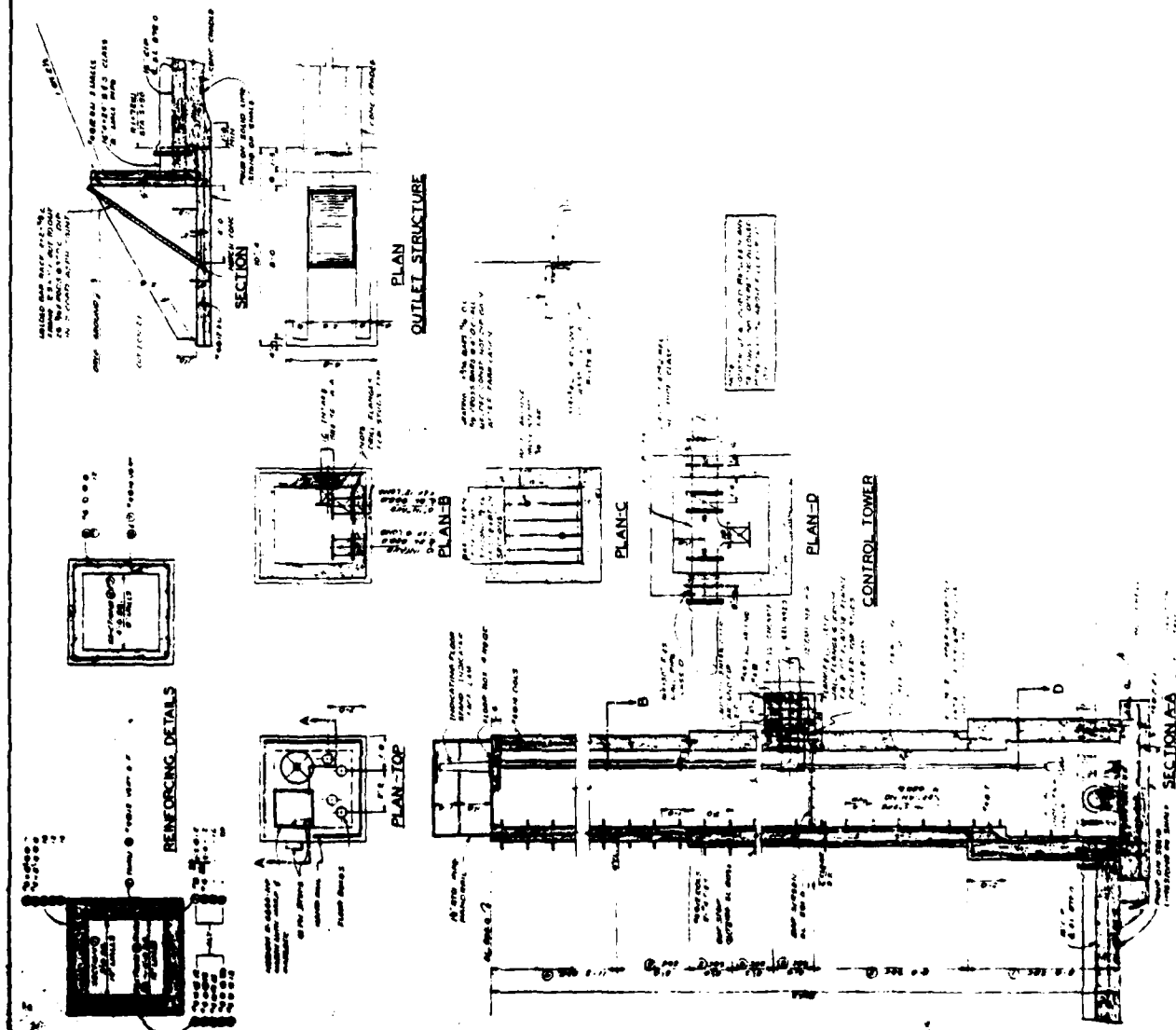
BETHANY, MISSOURI

Typical cross sections

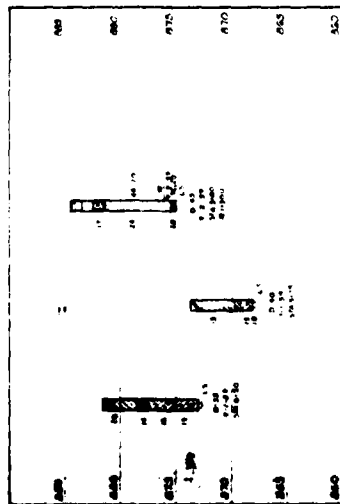
LARKIN & ASSOCIATES

Consulting Engineers

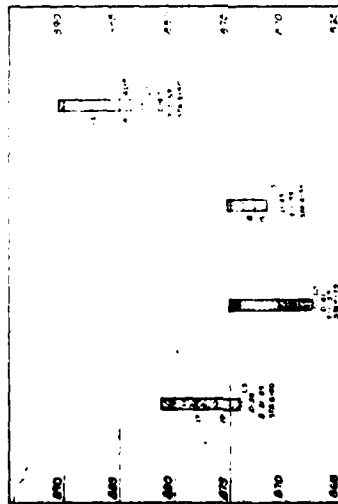
118



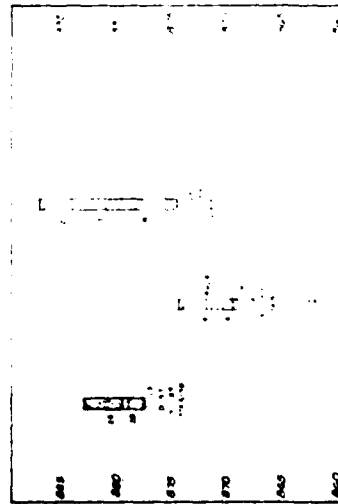
WATER SUPPLY IMPROVEMENTS	
BETHANY, MISSOURI	
LAWREN & ASSOCIATES	
Plan No. 100-100-100	
Scale: 1" = 10'-0"	
Date: 10/1/50	
Sheet No. 1 of 1	



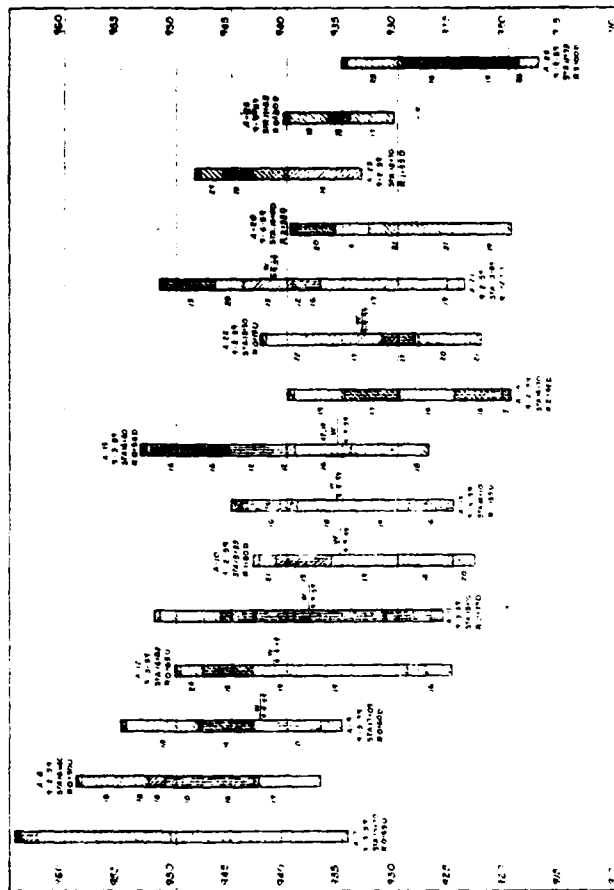
RANGE 1-25 U



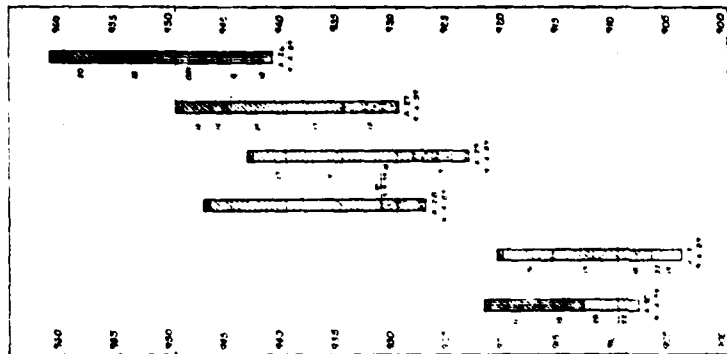
RANGE 0-50 D



RANGE 1-40 D



WEST BORROW AREA EXPLORATIONS



NORTHWEST BORROW AREA EXPLORATIONS

LEGEND

- 1. ALLuvial SANDS AND GRAVELS
- 2. CLAYEY SANDS
- 3. SILTY CLAY
- 4. CLAY
- 5. SILT
- 6. SAND
- 7. GRAVEL
- 8. COBBLES
- 9. Boulders
- 10. Unconsolidated
- 11. Consolidated
- 12. Hard
- 13. Soft
- 14. Very Soft
- 15. Very Hard
- 16. Very Stiff
- 17. Very Weak
- 18. Very Strong
- 19. Very Brittle
- 20. Very Ductile
- 21. Very Elastic
- 22. Very Inelastic
- 23. Very Compressible
- 24. Very Incompressible
- 25. Very Permeable
- 26. Very Impermeable
- 27. Very Absorbent
- 28. Very Non-absorbent
- 29. Very Hygroscopic
- 30. Very Non-hygroscopic
- 31. Very Acidic
- 32. Very Alkaline
- 33. Very Saline
- 34. Very Non-saline
- 35. Very Toxic
- 36. Very Non-toxic
- 37. Very Flammable
- 38. Very Non-flammable
- 39. Very Explosive
- 40. Very Non-explosive
- 41. Very Corrosive
- 42. Very Non-corrosive
- 43. Very Oxidizing
- 44. Very Non-oxidizing
- 45. Very Reducing
- 46. Very Non-reducing
- 47. Very Catalytic
- 48. Very Non-catalytic
- 49. Very Inert
- 50. Very Active

1. ALLuvial SANDS AND GRAVELS
2. CLAYEY SANDS
3. SILTY CLAY
4. CLAY
5. SILT
6. SAND
7. GRAVEL
8. COBBLES
9. Boulders
10. Unconsolidated
11. Consolidated
12. Hard
13. Soft
14. Very Soft
15. Very Hard
16. Very Stiff
17. Very Weak
18. Very Strong
19. Very Brittle
20. Very Ductile
21. Very Elastic
22. Very Inelastic
23. Very Compressible
24. Very Incompressible
25. Very Permeable
26. Very Impermeable
27. Very Absorbent
28. Very Non-absorbent
29. Very Hygroscopic
30. Very Non-hygroscopic
31. Very Acidic
32. Very Alkaline
33. Very Saline
34. Very Non-saline
35. Very Toxic
36. Very Non-toxic
37. Very Flammable
38. Very Non-flammable
39. Very Explosive
40. Very Non-explosive
41. Very Corrosive
42. Very Non-corrosive
43. Very Oxidizing
44. Very Non-oxidizing
45. Very Reducing
46. Very Non-reducing
47. Very Catalytic
48. Very Non-catalytic
49. Very Inert
50. Very Active

WATER SUPPLY IMPROVEMENTS	
BETHANY	MISSOURI
5-7-179	
LARKIN & ASSOCIATES	
Civil Engineers	
1000 1st St. N.E.	
Grand Rapids, Mich.	

APPENDIX D
HYDROLOGIC COMPUTATIONS

HYDROLOGIC COMPUTATIONS

1. The Mockes dimensionless standard curvilinear unit hydrograph and the SCS TR-20 program were used to develop the inflow hydrographs (see Plate D1). The inflow hydrograph for the 100-year flood was generated by the consultant using the TR-20 program.

a. Six-hour, twelve-hour, and twenty-four hour 100-year rainfall for the dam location was taken from NOAA Technical Paper 40. The 24-hour probable maximum precipitation was taken from the curves of Hydrometeorological Report No. 23 and current OCE directives furnished 3 August 1978.

b. Drainage area = 1.145 square miles.

c. Time of concentration of runoff = 44 minutes.

d. The antecedent storm conditions were heavy rainfall and low temperatures which occurred on the previous 5 days (SCS AMCIII). The initial pool elevation was assumed at the crest of the principal spillway.

e. The total 24-hour storm duration losses for the 100-year storm were 1.28 inches. The total losses for the 24-hour duration 1/2 PMF storm were 1.38 inches. The total losses for the PMF storm were 1.43 inches. These data are based on SCS runoff curve No. 89 and antecedent moisture conditions from SCS AMCIII.

f. Average soil loss rates = 0.05 inch per hour approximately.

2. The spillway discharge rating was developed using the upstream standard step backwater method to develop a water surface in the reservoir. There was no flow over the top of the dam.

3. Floods were routed through the reservoir using the TR-20 program to determine capability of the spillway. The storm rainfall patterns, inflow hydrographs and routed outflow hydrographs are given on Plate D1.

